



# Compiling Image Processing Applications for Many-Core Accelerators

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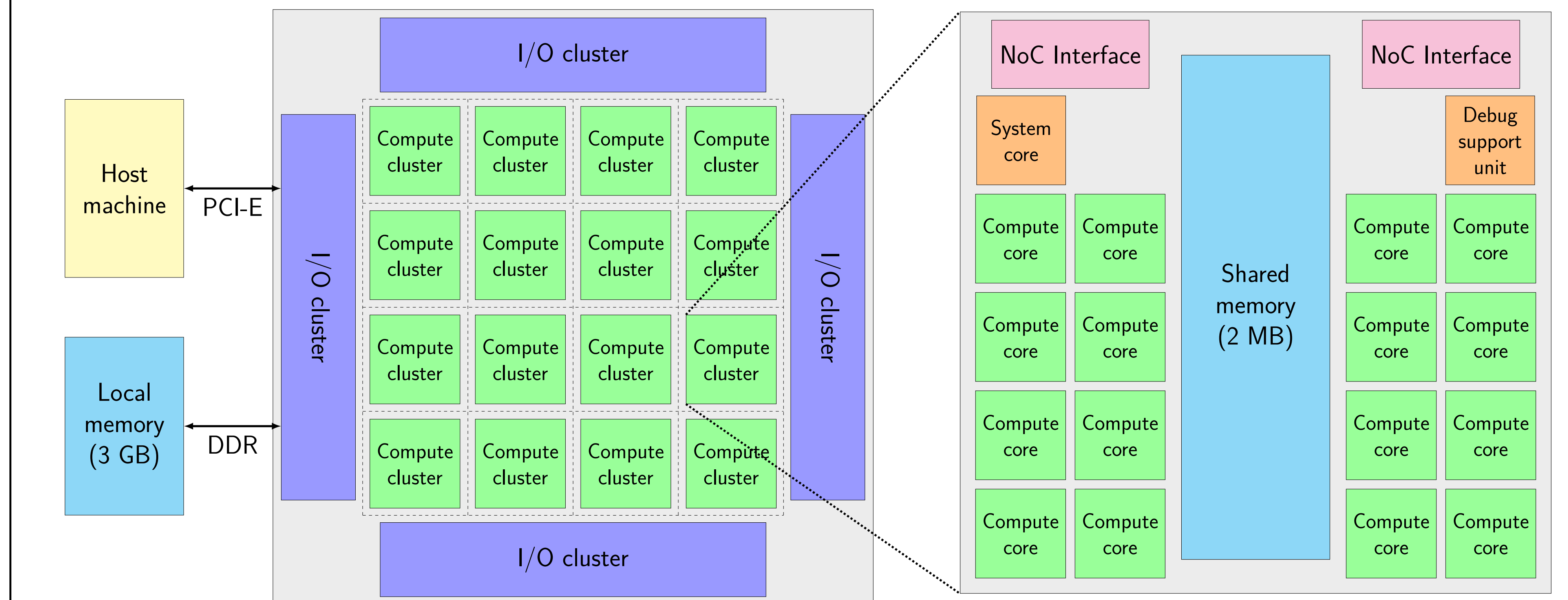
## Image Processing

**image analysis:** detect geometrical structures in an image  
**mathematical morphology:** image analysis theory and technique based on lattices theory

## Mathematical Morphology Base Operators

- arithmetic operators
    - unary (pixel  $\otimes$  parameter, 1 input image)
    - binary (pixel  $\otimes$  pixel, 2 input images)
    - $+$   $-$   $\times$   $\div$  min max  $=$   $\&$   $|$   $\sim$
  - morphological operators
    - stencils
    - neighbor selection + min/max/avg
  - reduction operators
    - global max/min/sum
  - other operators
    - threshold, mask, log2, ...
- $\Rightarrow$  *Sigma-C* agent library

## The MPPA-256 Chip



## Example: Licence Plate Extraction

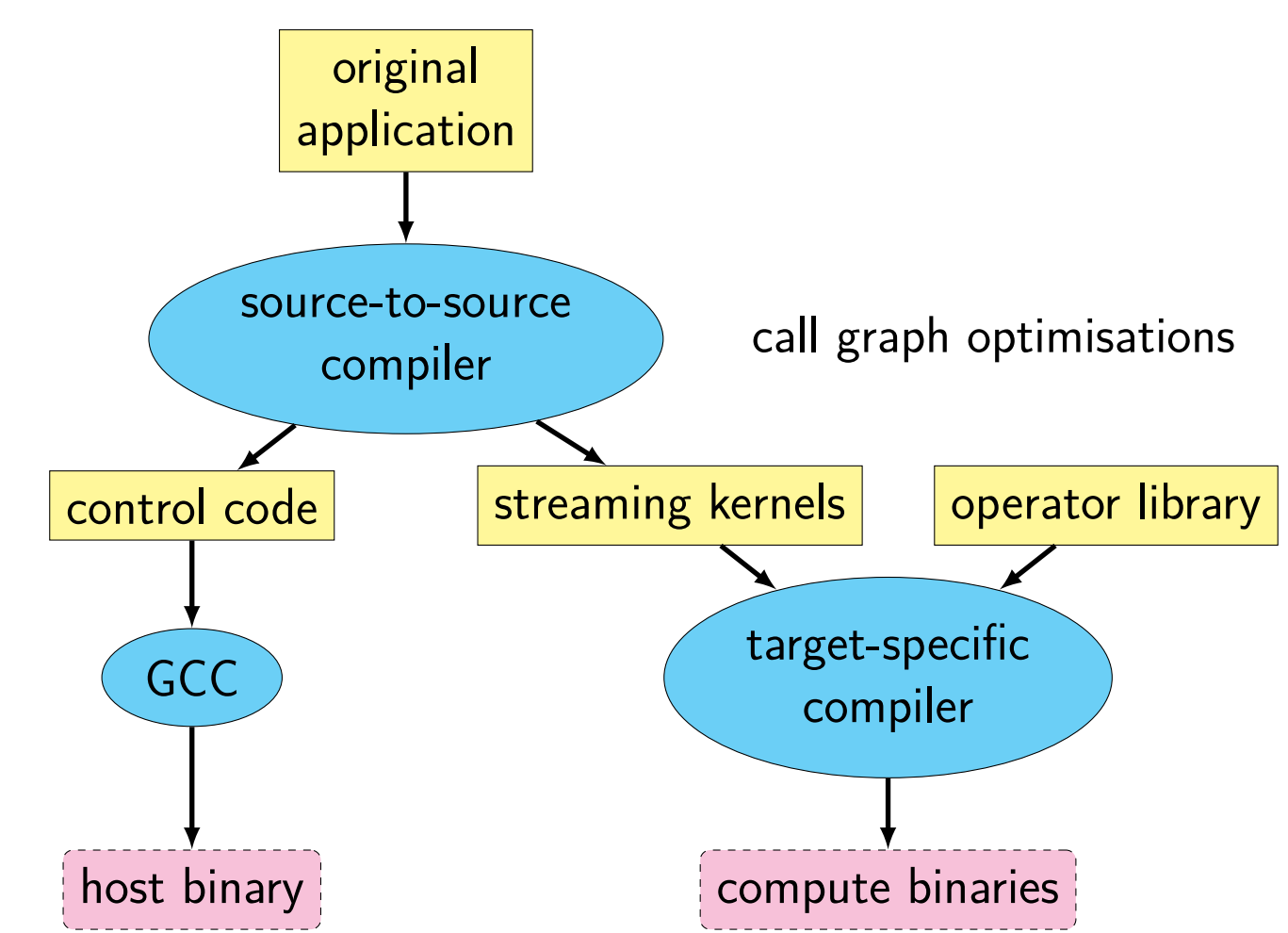


Input

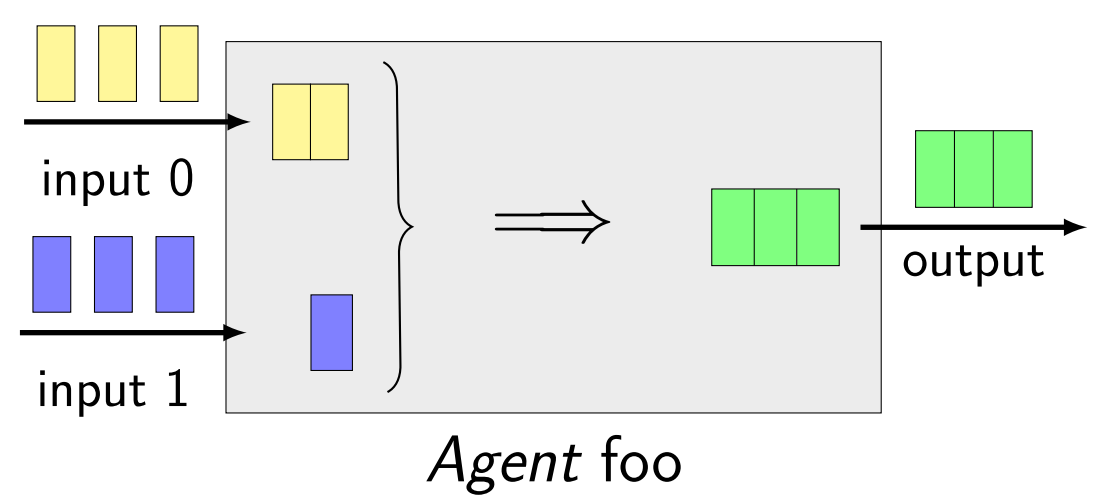


Output

## Compilation Chain



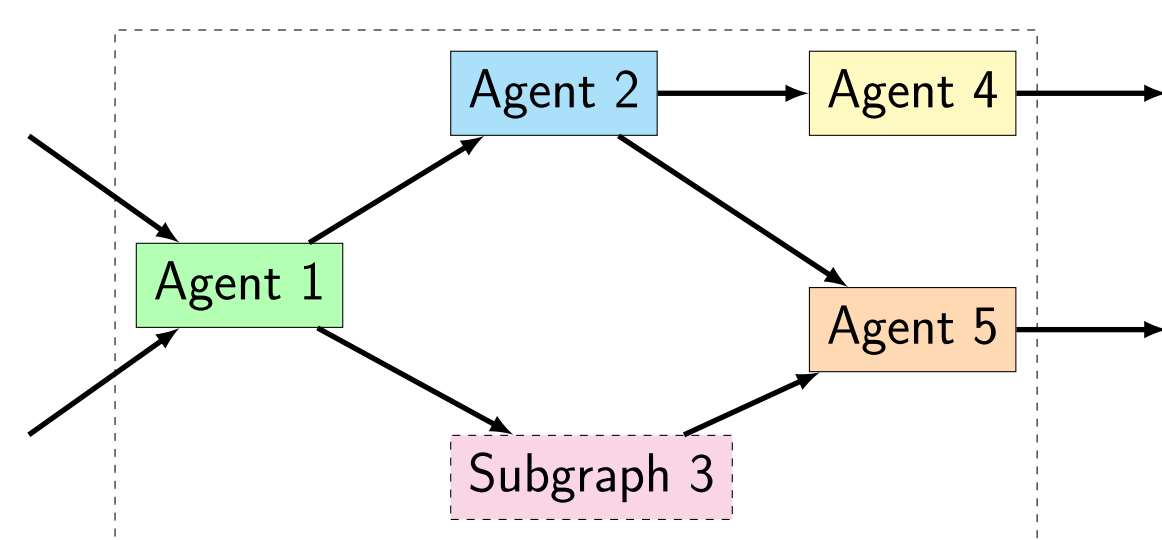
## *Sigma-C*, a Dataflow Programming Language



Agent foo

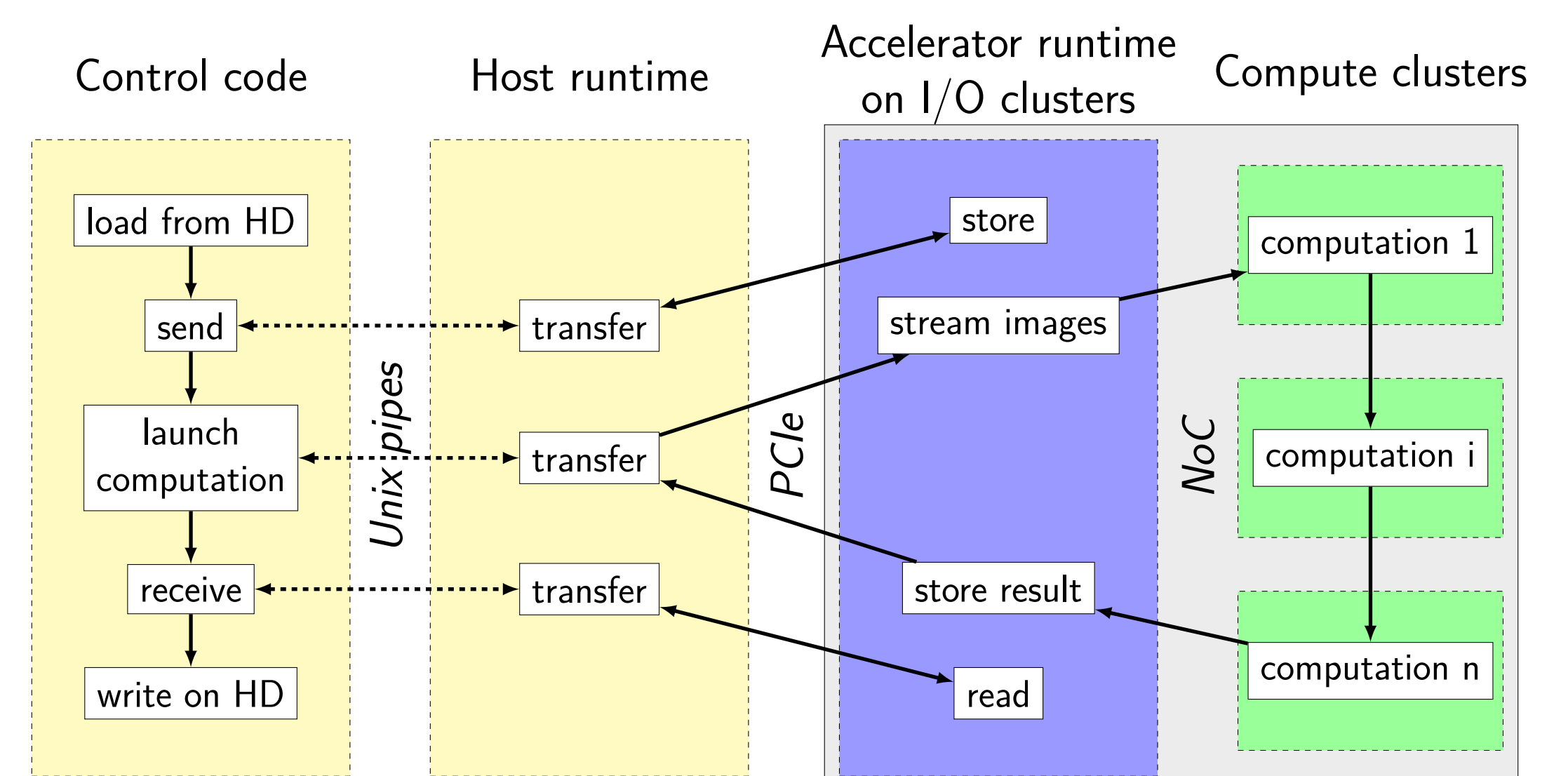
```
agent foo() {
  // describe agent interface
  interface {
    in<int> input0, input1;
    out<int> output;
    // declare the state machine
    spec{input0[2], input1, output[3]};
  }
  // loop over the state
  void start() exchange (input0 inp0[2], input1 inp1,
                        output outp[3]) {
    outp[0] = inp0[0];
    outp[1] = inp1;
    outp[2] = inp0[1];
  }
}
```

```
subgraph bar() {
  // describe subgraph interface
  interface { /* ... */ }
  map {
    // instantiate agents
    agent a1 = new Agent1();
    agent a3 = new Subgraph3(); // ...
    // connect agents to subgraph interfaces
    connect (input0, a1.input0);
    connect (a5.output, output1); // ...
    // connect agents
    connect (a1.output0, a2.input);
    connect (a3.output, a5.input1); // ...
  }
}
```



Subgraph bar

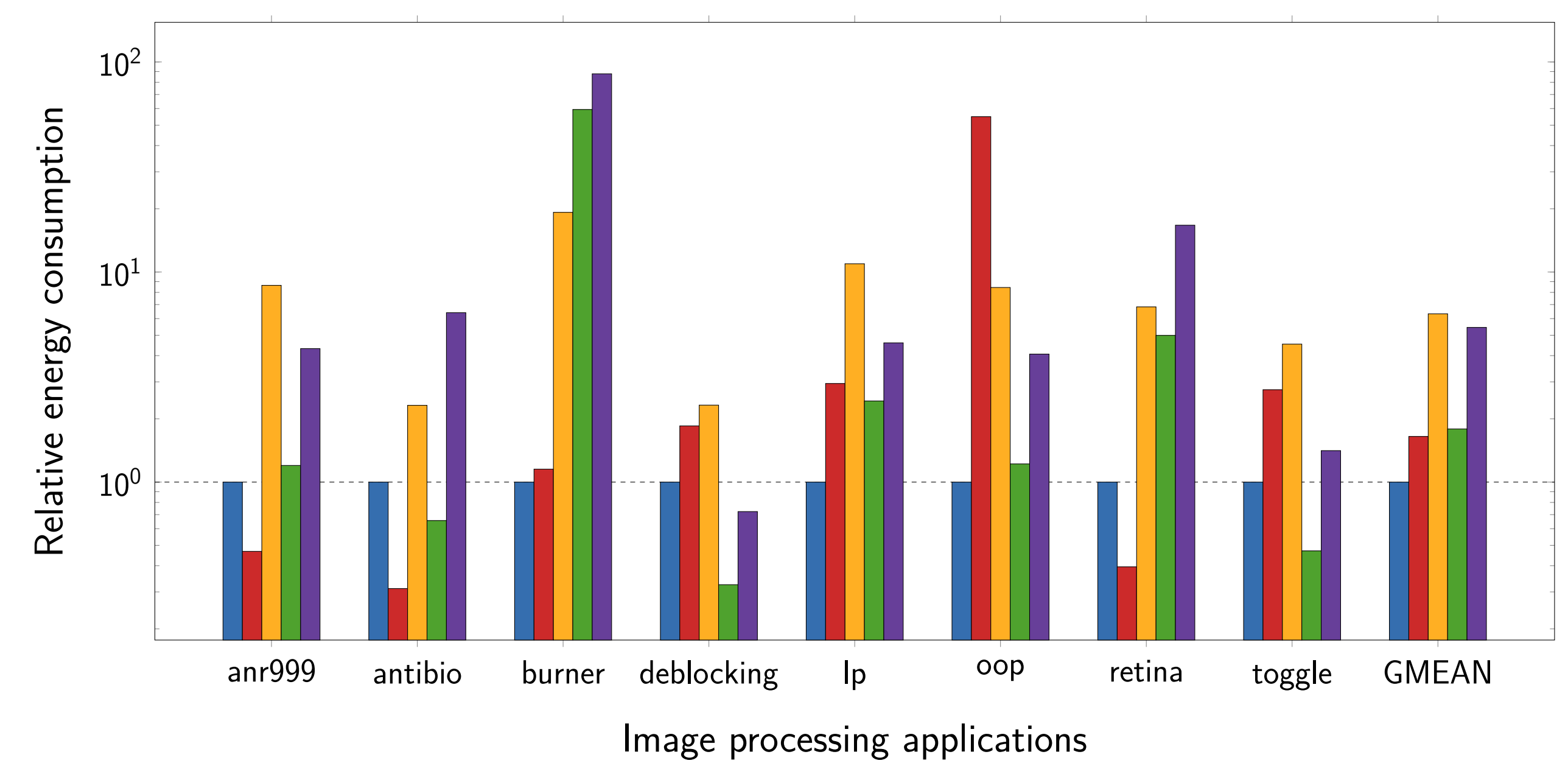
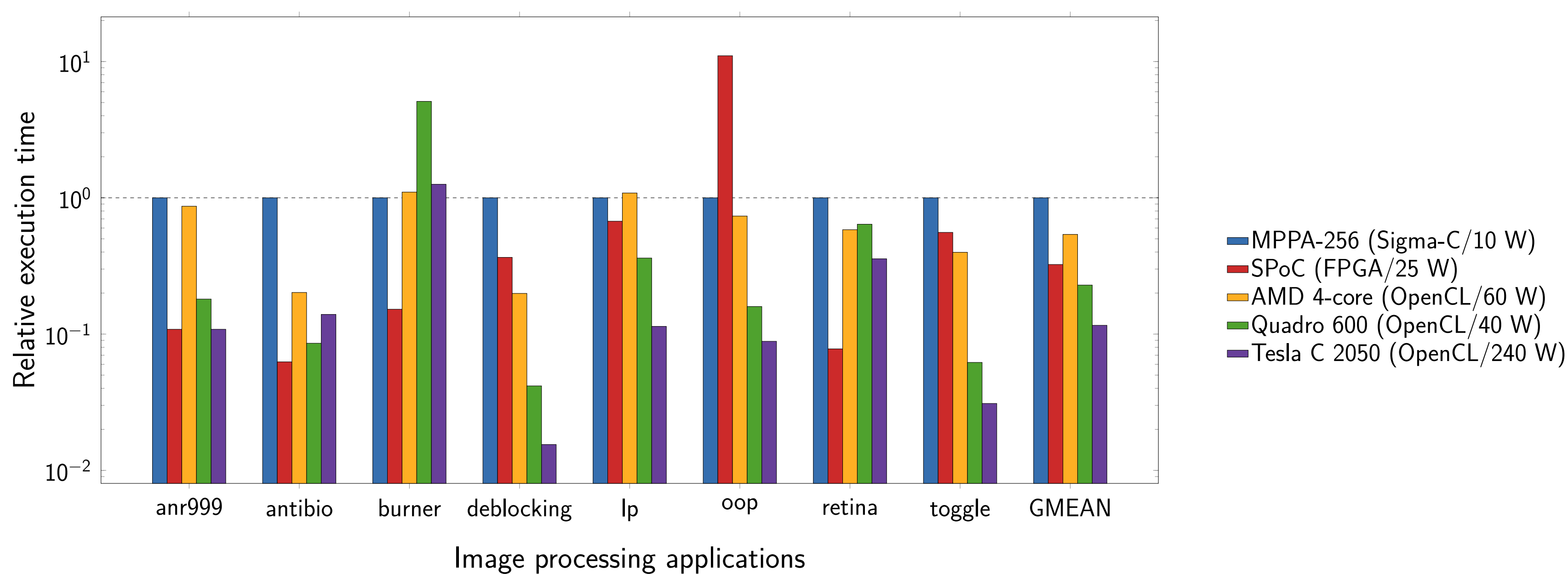
## Runtime Environment



## Optimisations

- unrolling of converging loops
- arithmetic operators aggregation
- generation of kernel-specific convolutions
- data parallelization for compute-intensive operators

## Results: Execution Times and Energy Consumption (MPPA-256 = 1, lower is better)



## Future Work

- Other programming models:
  - Pthreads/OpenMP on compute clusters, communication library between clusters
  - OpenCL via local memory pagination
- Improve data-parallelism to take better advantage of the current architecture
- Implement more complex algorithms: watershed, arrow, labelling, minima, ...

## References

Pierre Guillou, Fabien Coelho, and François Irigoin.  
 Automatic Streamization of Image Processing Applications.  
 The 27th International Workshop on Languages and Compilers for Parallel Computing (LCPC), 2014.  
 Available at <http://www.cri.enscm.fr/classement/doc/A-570.pdf>.

